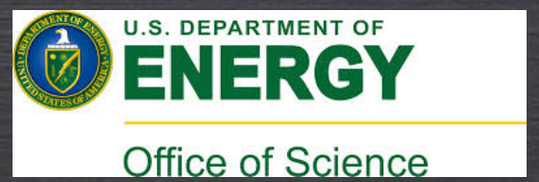
Challenges in coupling a high-resolution ice sheet model to CESM & ACME

Bill Sacks – National Center for Atmospheric Research (NCAR)
Bill Lipscomb – Los Alamos National Laboratory (LANL)

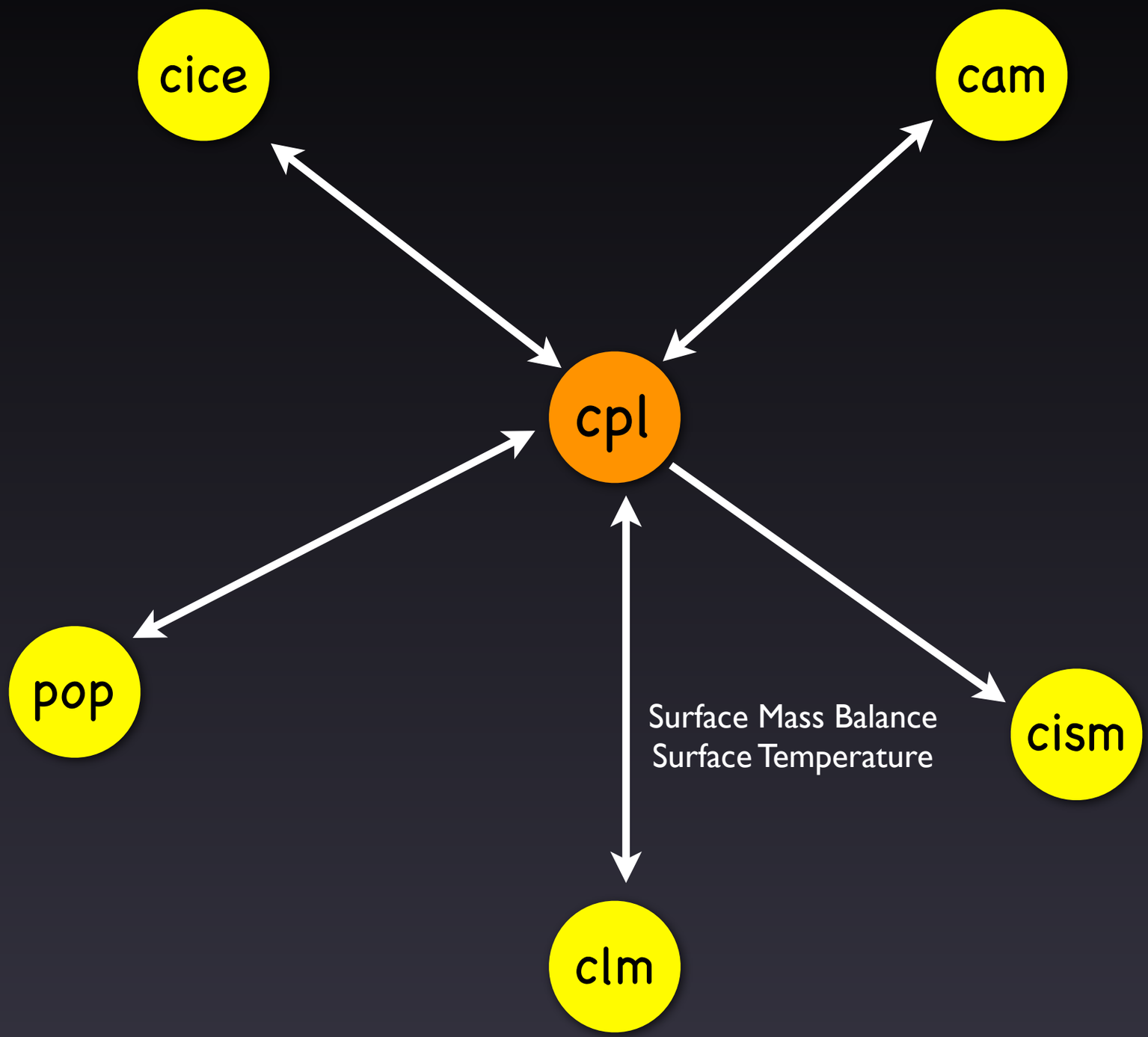
With substantial help from Jeremy Fyke (LANL), Mariana Vertenstein (NCAR) and Tony Craig



Challenge:
Long time scales (100s to 10s of thousands of years):
Static properties become dynamic

Two-Way Coupling

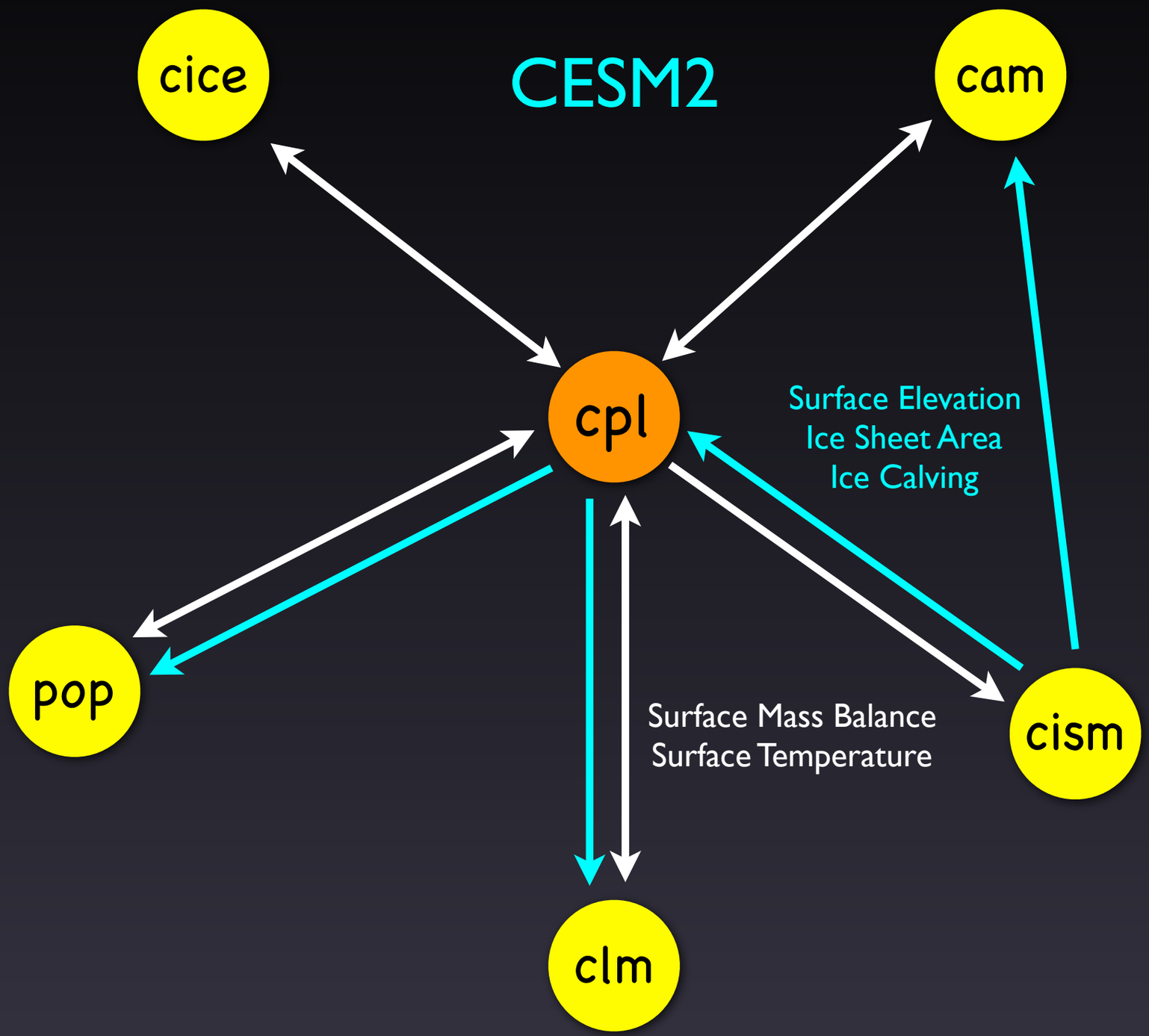
CESM1



Two-Way Coupling

CESM1

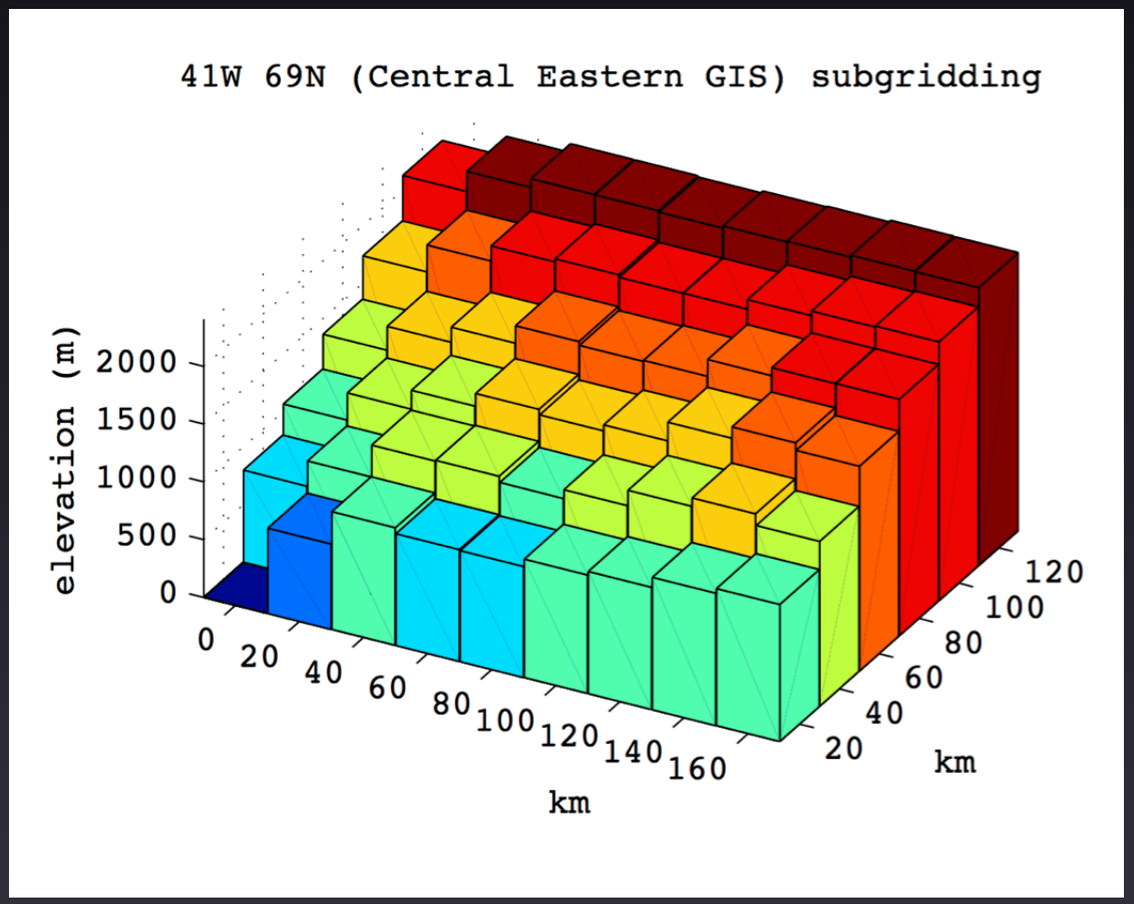
CESM2



Challenge:
Smooth, conservative mapping from land grid to high-resolution ice sheet grid

Elevation Classes to Help Reconcile Spatial Scales

Land model (~ 1 degree) computes surface mass balance in 10 elevation classes. This vertical information improves the downscaling to the high-resolution (~ 4 km) ice sheet grid.



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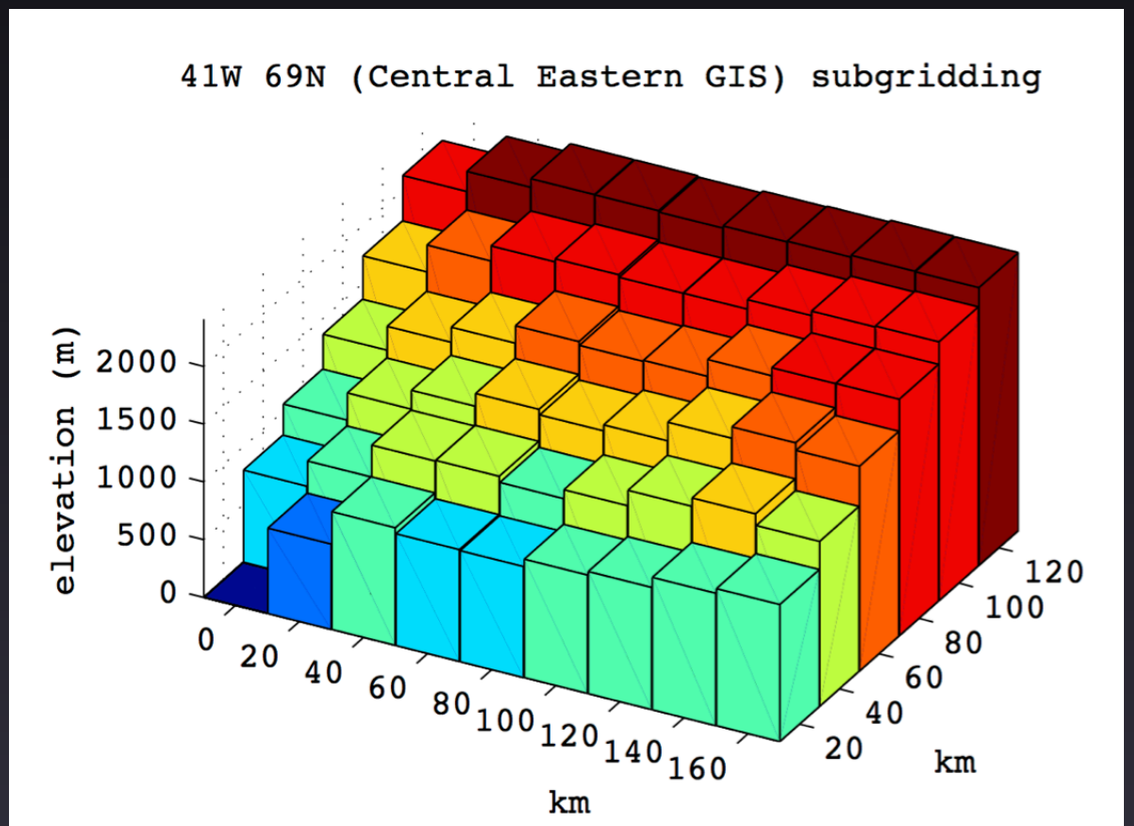

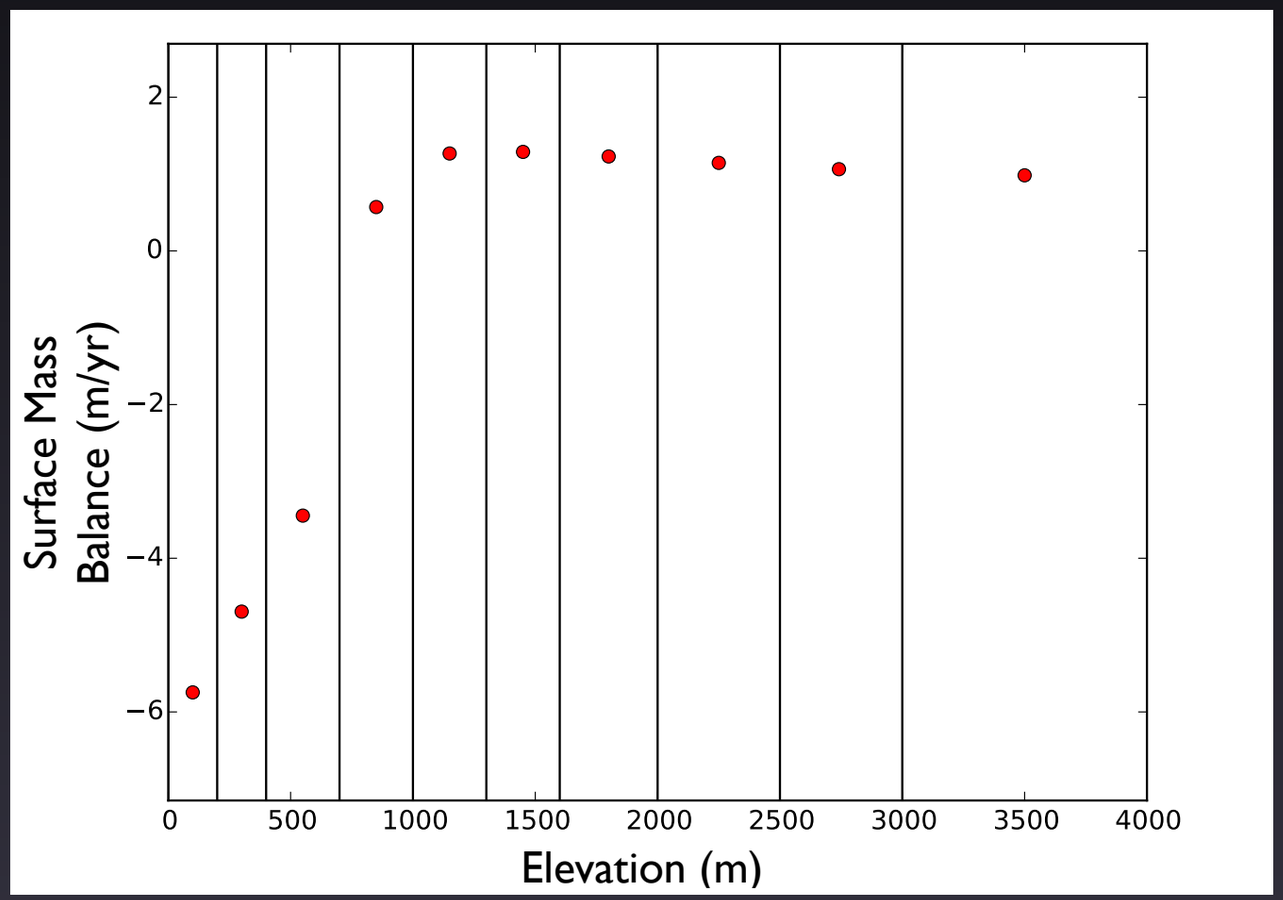

Moving Mapping into the Coupler

Originally: Remapping done in CISM (bilinear, non-conservative)

Moved remapping into the coupler:

- Allows conservative remapping
- Works with irregular land grids
- Makes it easier to bring in alternative ice sheet models
- For ice sheet-ocean mapping, don't need to map via land grid
- Allows parallel mapping

First Attempt:
First-order Conservative Remapping

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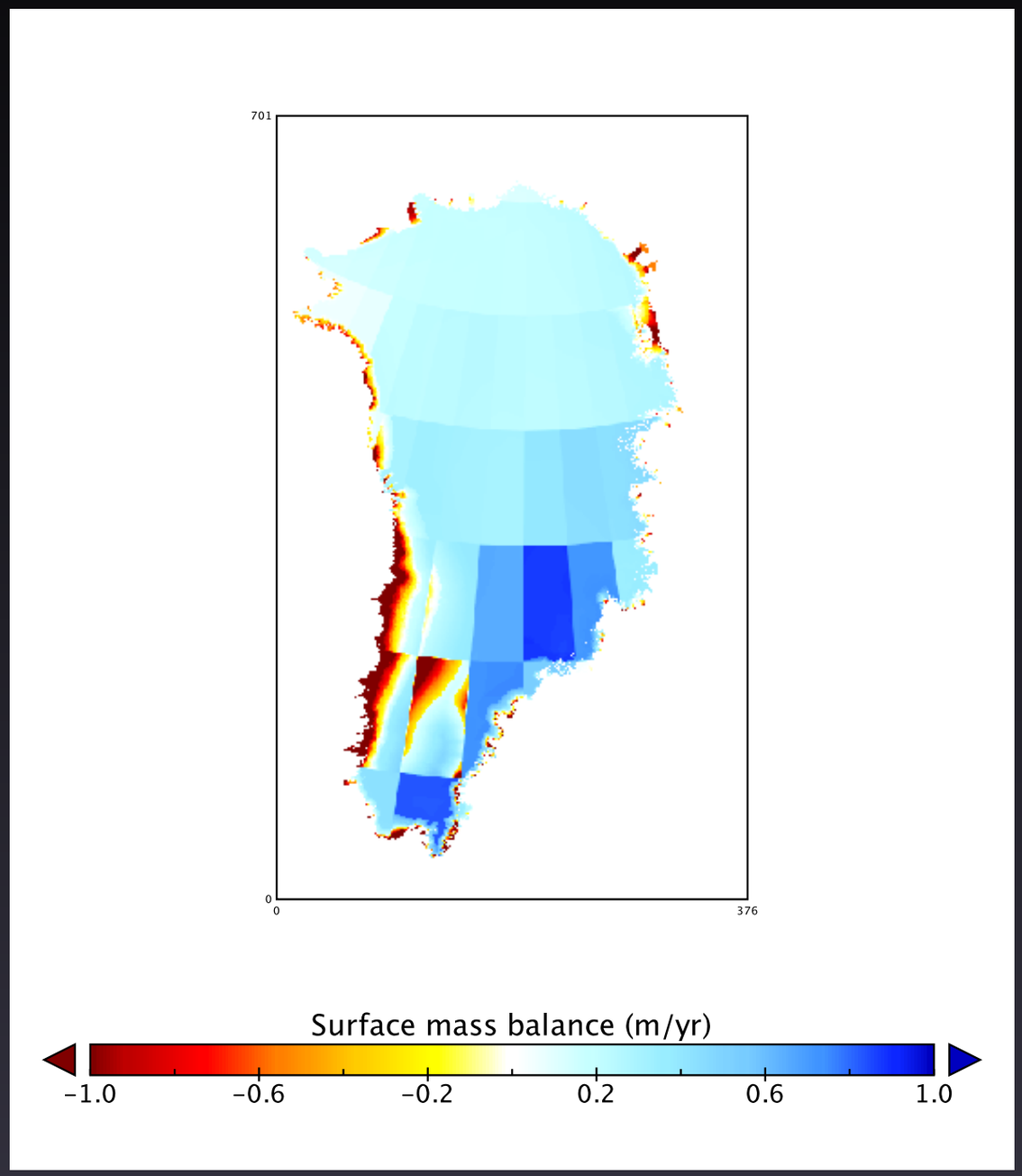
First-order Conservative Remapping



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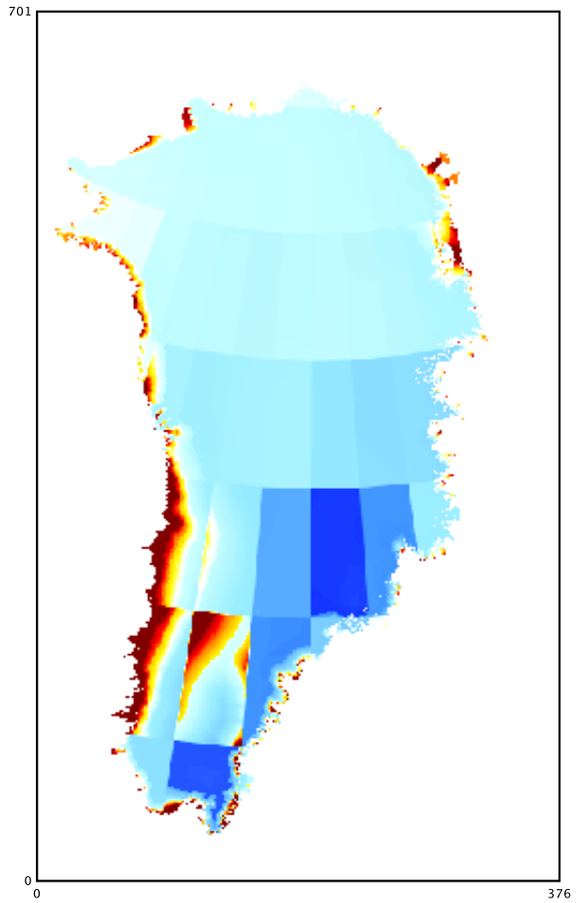

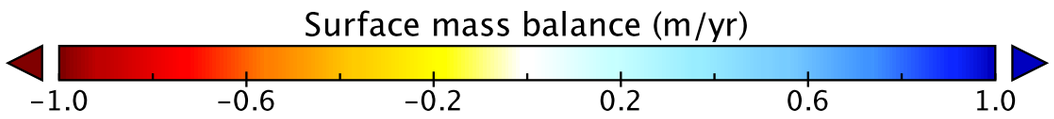

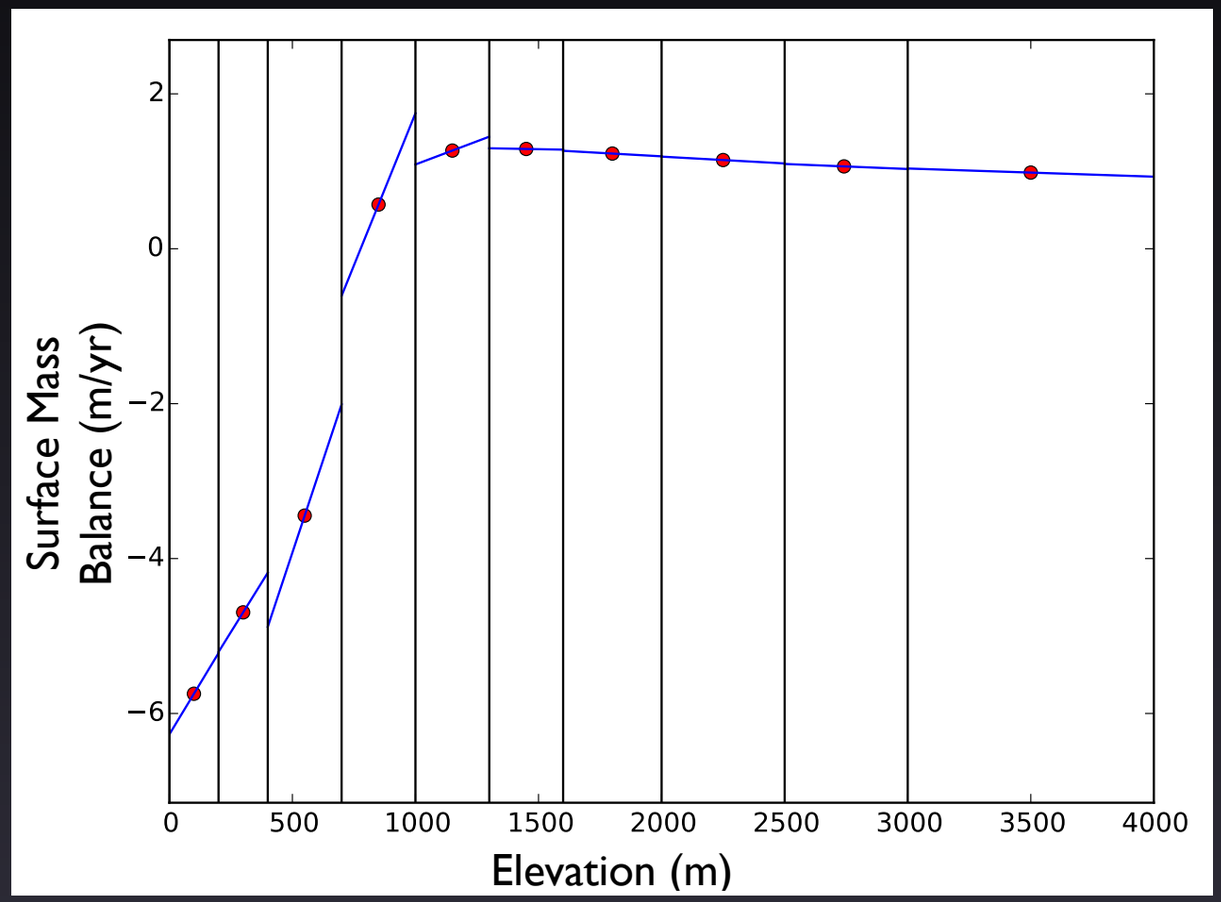

Alternatives Considered

Geosci. Model Dev., 7, 883–907, 2014
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A system of conservative regridding for ice–atmosphere coupling in a General Circulation Model (GCM)

R. Fischer[1,2], S. Nowicki[3], M. Kelley[2,4], and G. A. Schmidt[2]

[1]Center for Climate Systems Research, Columbia University, New York, NY, USA
[2]NASA Goddard Institute of Space Studies, New York, NY, USA
[3]NASA Goddard Space Flight Center, Greenbelt, MD, USA
[4]Trinnovim LLC, 2880 Broadway, New York, NY 10025, USA

Correspondence to: R. Fischer (robert.fischer@nasa.gov)

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Revised: 7 March 2014 – Accepted: 28 March 2014 – Published: 19 May 2014

- Clever solution allowing conservation with any regridding method from land to ice sheet

- But requires changing your land to atmosphere mapping

- Also: challenging to build the Glint2 library

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Second-order conservative remapping

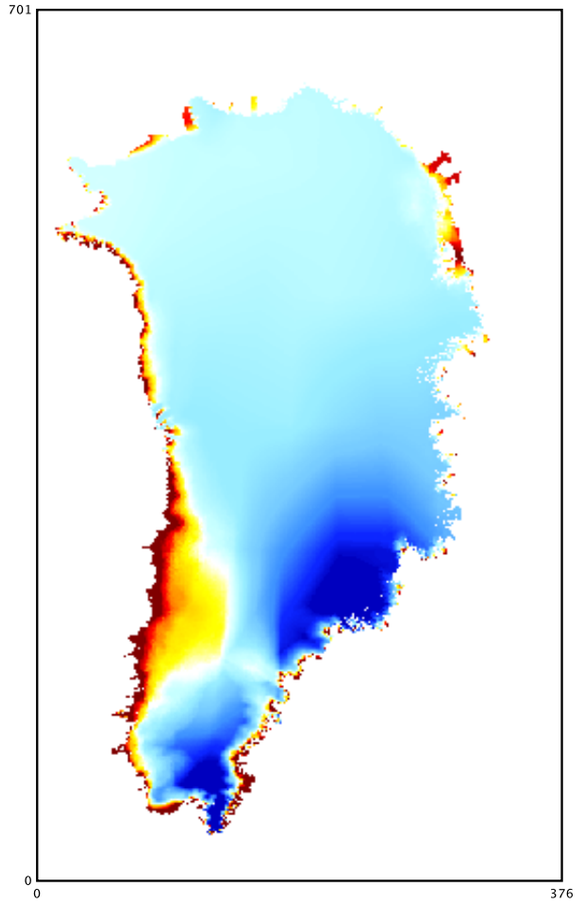
- Clever solution allowing conservation with any regridding method from land to ice sheet
- But requires changing your land to atmosphere mapping
- Also: challenging to build the Glint2 library

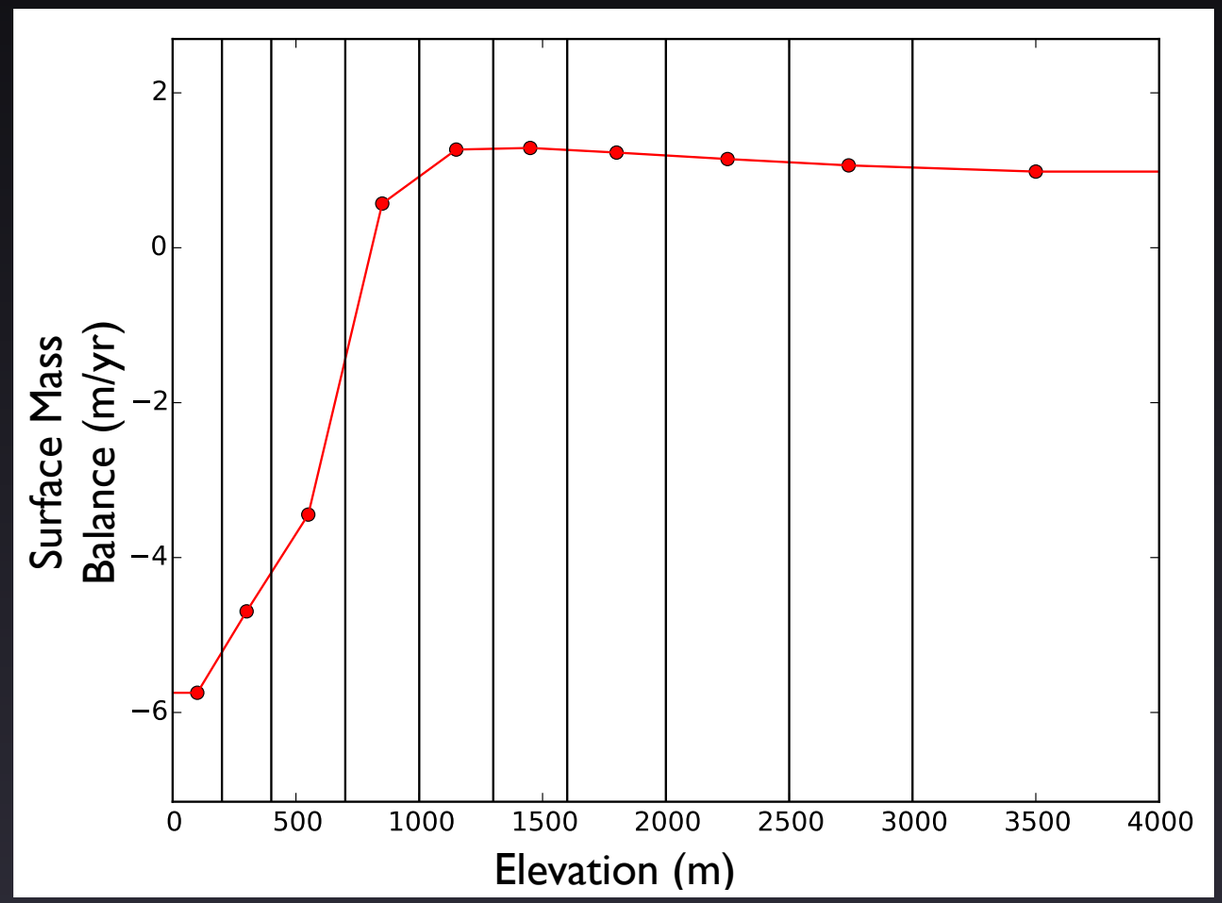
- Implementation wasn't ready
- Still *may* not be smooth enough once limiters are applied
- Possible option for the future (thanks, Bob Oehmke!)

Current Approach: Bilinear with Conservation Correction

- Multiplicative factors applied to achieve conservation
  - Separate factors for points with SMB > 0 and SMB < 0
- Generally, corrections less than 5%
- Subtleties for this to work right; for example:
  - How to handle partial grid cells (land fraction)
  - How to apply area corrections

Bilinear with Conservation Correction





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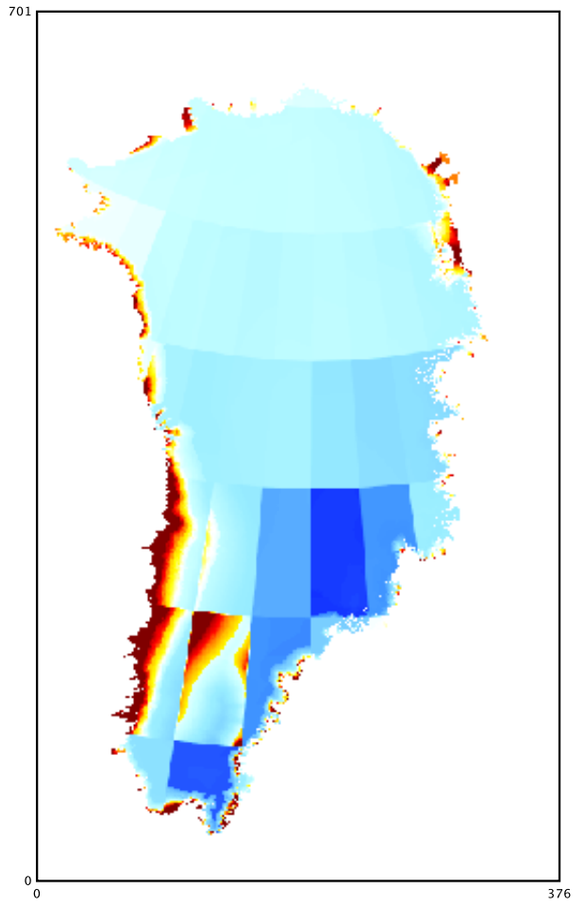
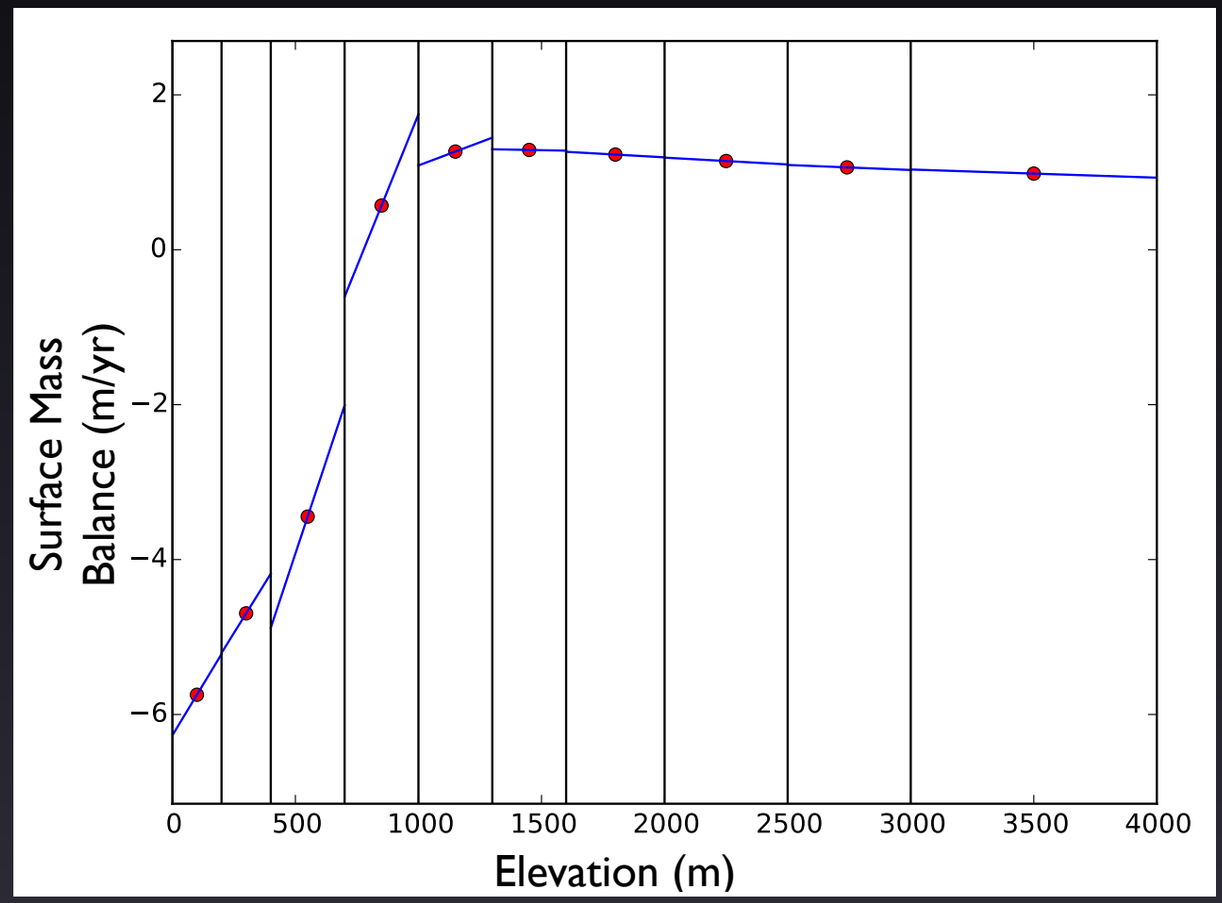
First-order Conservative Remapping





Side note:
Conservative, Continuous Vertical Remapping

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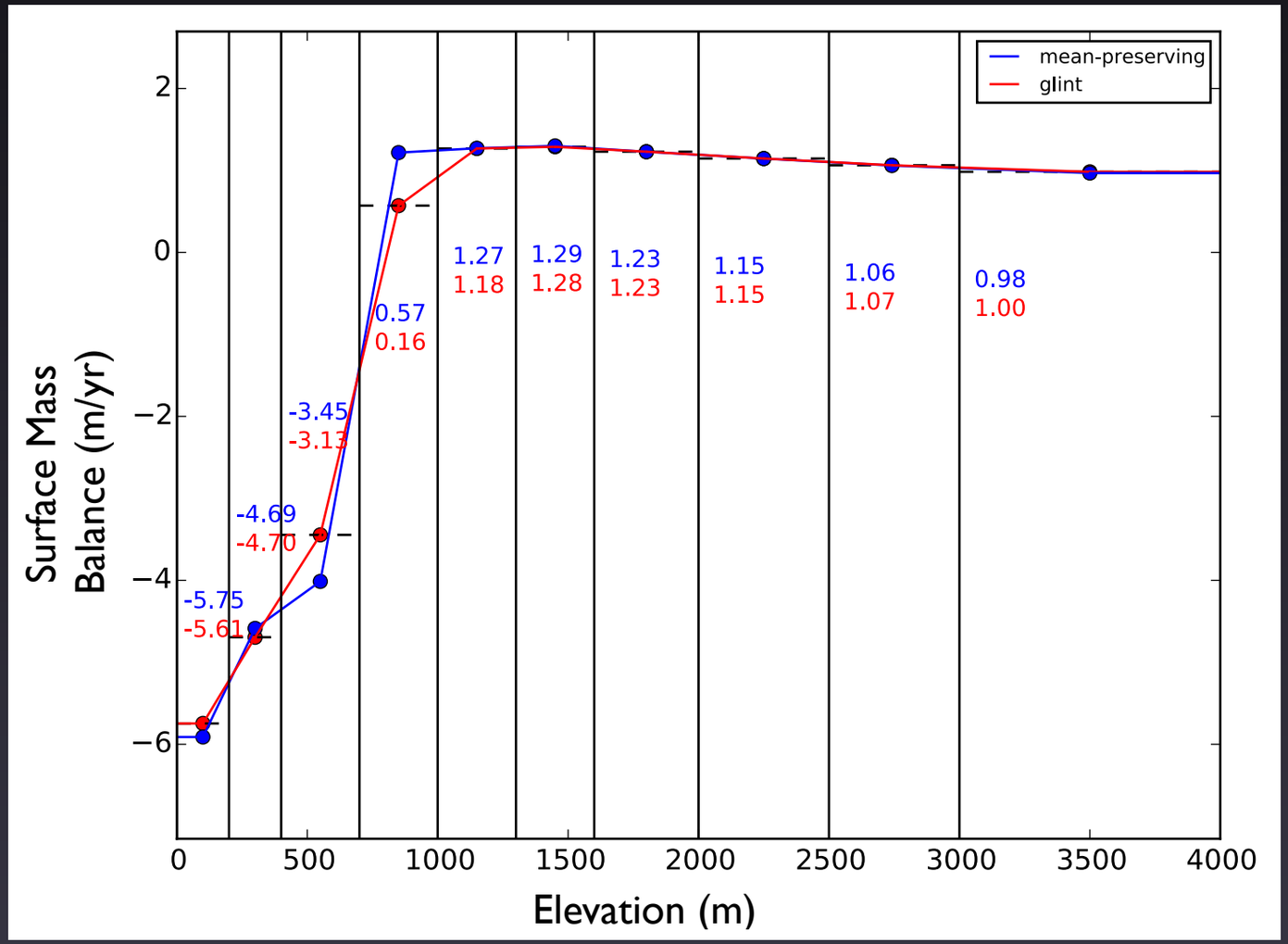
Time Interpolation of Forcing Fields in Ocean Models

PETER D. KILLWORTH*
NERC Oceanography Unit, Clarendon Laboratory, Oxford, England

3 January 1995 and 12 May 1995



Challenges with New Remapping

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- Global correction factor is unsatisfying
- Correction factors too large when applied to daily fields
  - Solution: Remap only annual averages
  - But still need to call the ice sheet model daily to support mid-year restarts
- Glacial inception (triggered by land model): remapping causes many ice sheet cells to become ice-covered; problem worse with bilinear remapping

Summary

- Coupling ice sheet models is challenging:
  - Long time scales
  - High spatial resolution
  - And ice-ocean coupling (not yet tackled for CESM)
- CESM2 can handle evolving ice sheets
- The downscaling problem has been a challenge
  - Current solution involves global conservation correction factors
  - Requires substantial custom remapping code